Novel Method For Teaching The Difference And Relationship Between Theories And Laws To Pre-Service Secondary Teachers And High School Students

By: Kathryn L. Gray and **Khadija E. Fouad**

Abstract

Rationale: The difference and relationship between theories and laws is commonly misunderstood by both secondary and post-secondary students (Lederman, 2010). People often hold the misconception that theories are more tenuous than laws, and that once a theory has been properly "proven" it can become a law (McComas, 1996). Simply explaining the difference and relationship to students is not particularly effective in removing this misconception (Howe & Rudge, 2005). Explicit and reflective instruction is best for the teaching of NOS concepts (Khishfe & Abd-El- Khalick, 2002).

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Novel Method for Teaching the Difference and Relationship Between Theories and Laws to Pre-Service Secondary Teachers and High School Students

Kathryn L. Gray & Khadija E. Fouad

Rationale

- The difference and relationship between theories and laws is commonly misunderstood by both secondary and post-secondary students (Lederman, 2010).
  - Theories provide explanatory frameworks for scientific phenomena
  - Laws describe regular patterns in natural phenomena
  - Non-hierarchical in nature
- People often hold the misconception that theories are more tenuous than laws, and that once a theory has been properly "proven" it can become a law (McComas, 1996).
- Simply explaining the difference and relationship to students is not particularly effective in removing this misconception (Howe & Rudge, 2005).
- Explicit and reflective instruction is best for the teaching of NOS concepts (Khishfe & Abd-El-Khalick, 2002).

Methods

- Qualitative action research on preservice teachers and high school students attending schools in the Southeastern US
- Pre-and post-tested by writing an answer to the following question from the VNOS-C questionnaire (Lederman *et al.*, 2002).
  - Is there a difference between a scientific theory and a scientific law? Illustrate your answer with an example.
- Pre- and post-tests were coded by both authors with interrater reliability of 83%.

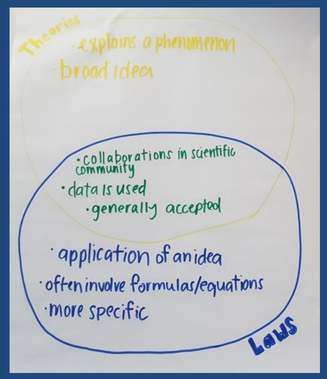
Pre-service Teachers

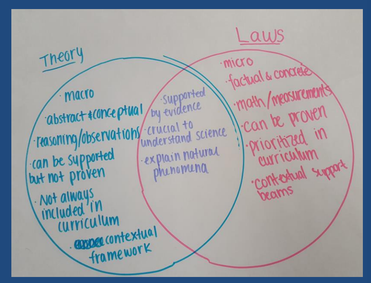
After the pre-test, students in groups of three or four listed all the scientific theories and laws they could recall. They were told that they could google information about the individual theories and laws if they wanted to refresh their memories, but not information about the general concept of theories and laws in science. They then examined their lists and determined the essential features of a scientific theory and of a scientific law. They constructed a Venn diagram of these features to share in a whole class discussion. Prior to the whole class discussions, students read an excerpt from Newton's *Principia*, mentioning that Newton's law of gravity was developed without a corresponding theory of gravity. Following the class discussion, the post-test was administered.

High School Students

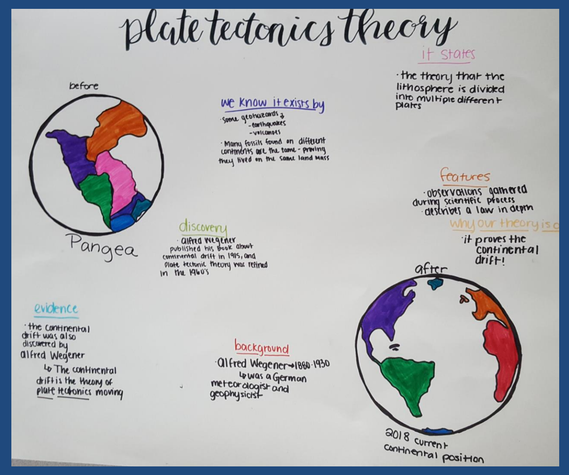
Students took a whole school day to research and develop their knowledge of the similarities and differences between scientific theories and scientific laws. They started with the pretest and also filled out a Venn Diagram stating what they know about theories and laws and how they intersect. The students recorded all of the theories and laws that they already knew. As a class they discussed what makes a scientific theory or law and created a large Venn diagram together. Students then read two articles about what defines scientific theory and a scientific law (Bradford 2017a & 2017b). In groups of four, students worked together to research one scientific theory or one scientific law. They created a poster about their theory or law, and included the essential features of a scientific theory or law. Students gave mini-presentations about their posters to their peers. As the students heard the presentations they filled out a T-Chart listing differences and similarities between the theories and laws. At the end of the day they completed the post-test and filled out a Venn Diagram about scientific theories and laws.

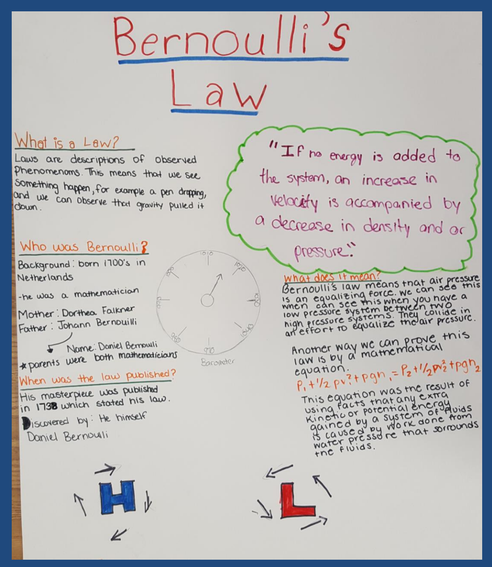
Pre-service Teachers





High School Students





Results

- Both college and high school students were able to gain more informed views of the difference and relationship between theories and laws as a result of explicit and reflective discussions to produce Venn diagrams.
- High school students needed more scaffolding than college students.
  - Definitions of scientific theories and laws were provided by articles that were short and to the point, and considered explicitly and reflectively by using annotation and discussion of the articles.
  - They learned the Big Bang theory, plate tectonic theory, and Kepler's laws of planetary motion prior to the scientific theories and laws activity.

Table
Pre- and post-test scores

	Pre-test		Post-test		Change
	Naïve	Informed	Naïve	Informed	
Preservice high school teachers	5	2	4	3	+1
Preservice middle school teachers	5	2	1	6	+4
High school students	82	1	51	30	+29

Note. Naïve responses represent both those that were clearly more naïve in their conceptions and those that were ambiguous.

Conclusions and Recommendations

- It was beneficial for both college and high school students to choose the theories and laws to use to produce their Venn diagrams, because it increased interest in the activity.
- College students can improve their conceptions when they complete the activity in a 50 minute class period.
- High school students need more than one class period to process the information.

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